A National Program of Research for

PLANTS TO ENHANCE MAN'S ENVIRONMENT

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

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Cochairmen

James M. Beattie, Assistant Director
Ohio Agricultural Research and
Development Center
Wooster, Ohio 44691

H. Rex Thomas, Director
Crops Research Division
Agricultural Research Service
Beltsville, Maryland 20705

Members

SAES

W. D. Holley
Department of Horticulture
Colorado State University
Fort Collins, Colorado 80521

Elliot C. Roberts
Professor and Chairman
Department of Ornamental
Horticulture
University of Florida
Gainesville, Florida 32601

James Tammen, Professor and Head
Department of Plant Pathology
211 Buckhout Laboratory
The Pennsylvania State University
University Park, Pennsylvania 16802

USDA

John C. Barber, Chief
Branch of Forest Genetics
Timber Management Research
Forest Service
Washington, D. C. 20250

W. H. Cummings, Principal Forester
Cooperative State Research Service
Washington, D. C. 20250

Gary C. Taylor, Chief
Environmental Economics Branch
Natural Resource Economics Division
Economic Research Service
Washington, D. C. 20250

L. A. Liljedahl, Chief
Crops Production Engineering Branch
Agricultural Engineering
Research Division
Agricultural Research Service
Beltsville, Maryland 20705

Floyd F. Smith
Investigation Leader
Vegetable and Specialty Crops
Research Branch
Entomology Research Division
Agricultural Research Service
Beltsville, Maryland 20705

Advisors

Elmer S. Atkins
Deputy Assistant Regional Director
National Capital Region
National Park Service
Department of the Interior
Washington, D. C. 20240

Raymond D. McKinney
Chief of the Program
Development Branch
Division of Land Development
Department of Housing and
Urban Development
Washington, D. C. 20410

Clarke W. Davis, Executive Secretary
National Arborist Association, Inc.
616 Southern Building
Washington, D. C. 20005

Truman Fossum
Florist Transworld Delivery Assn.
900 W. Lafayette Boulevard
Detroit, Michigan 48226

Robert F. Lederer
Executive Vice President
American Assn. of Nurserymen, Inc.
835 Southern Building
15th and H Streets, N.W.
Washington, D. C. 20005

Participating Staff Member

David J. Ward, Research Coordinator
Research Program Development
and Evaluation Staff, USDA
Washington, D. C. 20250

AUTHORITY

In response to a request from the Senate Committee on Appropriations, the U.S. Department of Agriculture and the Association of State Universities and Land Grant Colleges conducted a study of all agricultural research. This led to the October 1966 report, "A National Program of Research for Agriculture."

Recommendation 2, in Chapter VIII, Organization and Responsibilities for Agricultural Research, of the 1966 report, urged that *ad hoc* interdisciplinary committees of scientists provide in-depth reviews of designated research subject matter areas. Accordingly, the Chairman of the Experiment Station Committee on Organization and Policy and the Director of Science and Education appointed this task force to deal with the general area of natural beauty and ornamental horticulture.

PROCEDURE

Early in their deliberations, members of the task force recognized a need to establish parameters within which to identify and recommend research and

manpower needs. In the broadest sense these are implied by the name which the task force has adopted for its report: PLANTS TO ENHANCE MAN'S ENVIRONMENT.

The subject of the report was considered from the standpoint of Environment and Design and Research Program. The latter involved identification of researchable problems and opportunities for developing new knowledge about "Production," "Establishment and Maintenance," and "Marketing."

Though there is no discussion of research needs in the section on Environment and Design, the task force emphasizes that research concerned with the use of plant materials as design elements is important and should be significantly increased! A wide variety of trees, ornamentals, turf, and related plants exist, and there is a great need for research to determine the best means of utilizing them in the modification of man's functional and esthetic environment. Accomplishment of this research will require increased cooperation and coordination between plant scientists and landscape architects.

Within each of the three major headings under Research Program, attention is given to generalized commodity groupings:

(1) Turf and ground covers

(2) Trees

(3) Woody and herbaceous perennials, and bulbs

(4) Cut flowers, greens, pot plants, bedding plants, and foliage plants.

The sections in the Research Program portions of the report include discussions of Problems, lists of Research Needs, and tabulations of Manpower Needs. Current and projected scientist man-years (SMY's) 1/ are presented. The SMY's were considered from the standpoint of State Agricultural Experiment Station (SAES) and USDA programs. In keeping with the 1966 report, A National Program of Research for Agriculture, the SAES and USDA programs were considered within the framework of several Research Problem Areas pertinent to the subject of this report.

1/ A SMY is defined as the research time of an assistant professor, or GS-11, or above, for one year. When expressed as an average cost per SMY in dollars, it includes his salary plus that of support personnel (such as secretary, technician, etc.), plus regular operating funds (such as travel, publication costs, instrumentation, and expendable items). It does not include the cost of the facility within which he conducts his research.

The task force was interested in presenting as accurately as possible the current SMY's directed to the scope of the problems identified as applying to the use of "plants to enhance man's environment." From one viewpoint, it could be reasoned that all research in genetics, physiology, silviculture, plant pathology, entomology, weed control, soils, and similar areas contributes to effective use of plants for environmental improvement. This would involve many of the research problem areas (RPA's) cited in A National Program of Research for Agriculture. However, it was decided to include only the following:

(1) All research classified in RPA 905 1/--Trees to enhance rural and urban environment and RPA 906--Culture and protection of ornamentals and turf.

(2) Research involving the plants considered by the task force in RPA 103--Management of salinity and saline soils, RPA 105--Conservation and efficient use of water for agriculture, and RPA 214--Protection of plants and animals from harmful effects of air pollution.

(3) In RPA 201--Control of forest insects and RPA 202--Control of diseases of forest trees, only that research closely related to problems of urban and suburban areas.

The SMY's projected in this report for the last two RPA's are also included in the report of the Forestry Research Task Force.

The task force acknowledges that research in other RPA's 2/ contributes to principles that may be used in research on plants to enhance man's environment. However, it is too difficult for the purposes of this report to determine how much of the research in each of these should be so identified.

1/ A RPA shown in A National Program of Research for Agriculture as IX-5, for example, is cited in this report as RPA 905.

2/ Among possible RPA's not included in this report are: 102--Soil structure and soil, plant, water nutrient relationships; 106--Efficient drainage and irrigation systems and facilities; 204--Control of insect pests of fruit and vegetable crops; 205--Control of diseases of fruit and vegetable crops; 206--Control of weeds and other hazards in fruit and vegetable crops; 207--Control of insect pests of field crops; 208--Control of diseases of field crops; 209--Control of weeds of, and other hazards to, field crops; 304--Improvement of biological efficiency of fruit and vegetable crops; and 307--Improvement of biological efficiency of field crops.

INTRODUCTION

Today, across this great country of ours, there is an unprecedented awareness and concern about the environment in which we live. Not only does this interest center around the air, soil, and water which sustain life; there also is great concern with regard to the role of trees, ornamentals, turf, and related plants in making man's life more pleasant.

This was brought to the attention of the American public by the late President John F. Kennedy in a special message to the Congress in February 1962 when he spoke on the Nation's natural resources. He pointed out in this address the inadequacies of our present facilities and resources to meet the needs of a fast-growing and increasingly mobile population.

Beginning in 1965, President Lyndon B. Johnson delivered a special message to Congress each year on this subject. In the first of these, the President said:

> "To deal with these problems will require a new conservation. We must not only protect the countryside and save it from destruction, we must restore what has been destroyed and salvage the beauty and charm of our cities. Our conservation must not just be the classic conservation of protection and development, but a creative conservation of restoration and innovation. Its object is not just man's welfare but the dignity of man's spirit."

Out of this observation--and this challenge--many Federal, State, and city programs have evolved. Numerous efforts have been made to discuss, explore, and improve the physical environment and natural beauty of our country.

Never before in the history of the United States have individuals, families, and communities taken so much interest and pride in improving and beautifying the homes, communities, and countrysides in which they live.

As a people, we are in the midst of an accelerated environmental change that touches all segments of our lives. We are an urban society and are becoming increasingly so. It is estimated that by 1977 the U.S. population could reach 230,000,000 persons. This is an increase of approximately 15 percent in a ten-year period. It is further estimated that approximately 75 percent of the population will be living in urban areas by 1977. This means new homes, apartments, schools, parks, and other developments that require the use of plants for protective and esthetic values.

The President's Citizens' Advisory Committee on Recreation and Natural

Beauty recognized a significant aspect of this in its 1968 Annual Report when it said:

> "We are faced with an immediate and specific crisis in conservation--the destruction and deterioration of the trees in our cities and suburbs.
>
> "Trees are an integral part of our town and cityscape. They give scale and proportion to our buildings. They subdue the harshness of too much stone and concrete. Trees lend charm and comfort to the crowded, often unlovely urban scene. Yet, the care and conservation of this valuable element of the urban environment has been largely neglected. Hostile growing conditions, unchecked diseases, and inadequate skilled care are taking a heavy toll of these important urban assets."

Plants serve the American public functionally, esthetically, and psychologically. They also represent a significant portion of the total economy of our affluent society and, more importantly, an aspect of the economy which is on the increase.

Consumer expenditures for goods and services related to trade in florist, nursery, bulb, flower seed, and turf crops amount to about $2.5 billion annually. Approximately three-fifths of this retail and service trade is the business of specialized establishments identified as retail growers, garden supply stores, and retail florists. The remaining two-fifths takes place in establishments which are not identified as specialists in producing or distributing these goods and services.

The number of farms identified with production of ornamental horticultural crops increased from about 35,000 in 1945 to 40,000 in 1965, while total farms in the U.S. declined from nearly 6 million to slightly over 3 million. This was the only classification of farm unit showing an increase in numbers for this period. Although later figures are not available, there is reason to believe that there has been a further increase since 1965.

Based on current USDA Farm Income Situation data, it is conservatively estimated that the wholesale value of non-food greenhouse and nursery crop production amounts to about $750 million annually, an increase of $519 million in 20 years. Recent surveys by private industry estimate that the increase is even higher than this.

Major portions of the wholesale, retail, and service trade dependent on non-food horticultural crop production are conducted by farms, specialized wholesalers, retail florists, and garden supply stores. The labor force represented by production and these portions of distribution of non-food horticultural crops consists of more than 50,000 owners and operators, more than 100,000 paid full-time workers, and an additional 100,000 paid part-

time workers. It is, therefore, the principal source of livelihood for more than 150,000 families in the United States and partial occupation and livelihood of an additional 100,000 individuals or families.

Foreign trade in tree, florist, nursery, bulb, and flower seed crops is also important. The declared value of such imports is about $20 million annually, more than one-half of which is accounted for by bulb crops from the Netherlands and one-fourth of which consists of Christmas trees from Canada. The declared value of exports of such crops is about $10 million annually. Existing levels of activity are no indication of the potential for growth in foreign trade when progress in technology, communications, and transportation permit international movement comparable to that which now takes place between States and regions of the United States.

Those concerned with producing and using plants are faced with many problems needing solution. Home gardeners, nurserymen, city foresters, landscape architects, park managers, and city planners need to have plants classified for environmental adaptation and special use characteristics. Specific plant characteristics are required for urban, suburban, transitional, rural, and controlled environments. Many of the new shopping centers are completely enclosed and plant requirements are very demanding. There is need to reduce noise around airports and major roads in cities. Production costs are high and new and improved methods of mechanization are needed.

Turf species are needed for those sections of the country that cannot satisfactorily grow either cool or warm season types. New pest resistant varieties of ornamentals are required to reduce the costs and hazards of chemical control for nurserymen, florists, and homeowners.

There is a recognized need for an urban and community forestry research program that will solve problems of the use of trees, shrubs, and related plants to improve the human environment. Information is needed on the selection, establishment, and culture of these plants for special uses such as noise abatement, reduction of air pollution, and modification of temperature. We need additional research on the culture of stands of trees and shrubs in and near communities to provide recreational opportunities, watershed protection, esthetic enjoyment and habitat for nongame animals and songbirds. Continued vigor of these plant communities is critical to long-term use and enjoyment by man.

Many of our trees are dying in cities and towns because of a lack of effective methods of controlling pests or because they are not tolerant to toxic air pollutants or to compounds used to remove ice from the streets. New cultivars are needed that will resist pests and thrive in adverse environments. Improved maintenance practices must be developed to restore vigor to existing trees and to reduce storm damage.

Shelterbelts have been an important factor in the Great Plains area, but

only a small portion of those needed have been established. There is a pressing need for breeding improved trees and shrubs that will successfully grow under the extreme environments. Also, more effective pest control measures must be developed to protect existing windbreaks and the new ones being established. Improved cultural practices are needed for rehabilitation of older belts to restore maximum effectiveness. Studies of the effects of windbreaks can help us to choose the most effective designs for new plantings.

Ornamental plants are being most economically produced in areas where the climate is most favorable, such as California and Florida. This requires the transport of plants over long distances. Problems exist in having the plants arrive in a desirable condition and in storing them until marketed. To further develop the ornamental industry on a sound basis, more data are needed on production, marketing, and price relationships.

Most of our ornamental plants are grown from seed, cuttings, and bulbs. Only a few locations in the United States are adapted for seed production, much of which is conducted under plastic-covered areas. We need methods to accelerate the production of useful hybrids which are vigorous, uniform, earlier and freer flowering than regular cultivars. Flower seeds must germinate well and easily, the seedlings must have resistance to unfavorable environments and be adaptable to many types of merchandising. Cuttings are produced out-of-doors in Florida and California. Techniques must be developed to produce disease-free cuttings from stable clones and to adapt the plants for reduced cropping times. Bulbs are now produced primarily in the Pacific Northwest. Proper management practices in the production, digging, storing, transporting, pre-cooling, and forcing of these bulbs throughout the United States must be strengthened through on-the-spot research programs. Peak demand for bulbs varies from year to year. Disease losses, flower count, and uniformity of flowering are constant problems for bulb growers.

The need for new knowledge makes it essential for the U.S. Department of Agriculture, the State agricultural experiment stations, the private sector, and others to provide the very best information about selecting, improving, establishing, protecting, maintaining, and marketing plants for home, farm, landscape, and special purpose plantings.

A research program has been developed which envisions not only a study on the effect of an environment on turf, trees, ornamentals and related plants, but also the effect of these plants on an environment. Implementation of this research program will permit the selection of plants which are best suited for use under various environmental conditions, and ensure that they be properly planted and maintained so that they reach their full potential in improving the human environment.

The proposed research would provide the knowledge and technology that is required for effectively and efficiently using plants in environmental

improvement programs. Past research accomplishments provide a reservoir of information, ideas, concepts, and techniques that can be used. But, the ever increasing need to reduce the costs and increase the effectiveness of improving the quality of our total environment will require new knowledge, ideas, and techniques. The overall objectives of research proposed by this task force are to provide alternative ways to use trees, shrubs, ornamentals, turf, bulbs, cut flowers, foliage, and other plants for:

1. Improving and maintaining the physical and esthetic qualities of the human environment in both urban and rural areas;

2. Protecting man, animals, and property from excessive heat, cold, light, wind, noise, snow, dust, and other suspended matter;

3. Managing urban forested lands and shelterbelts for multiple purposes.

It is through a dedicated research program such as this that we can adequately meet the challenge that two of our past Presidents have laid before us.

To make significant advances in providing the answers to some of these problems it is estimated that the current 300 scientific man-year effort needs to be increased to 699 over the next ten-year period.

TABLE 1

Summary of scientist man-years (SMY's) for research on plants to enhance man's environment

COMMODITY	SMY's	
	Estimated 1966 base	Projected 1977 total
Turfgrass, etc.	32	95
Trees	95	284
Perennials and bulbs	76	157
Cut flowers, etc.	97	163
TOTAL	300	699

Additional information about SMY's is shown in sections on Production; Establishment and Maintenance; and Marketing. Detailed tabulations are included under a section on Manpower Needs near the end of the report.

ENVIRONMENT AND DESIGN

We are confronted with a continuum of environments from rural to the central city and must know what plant materials will do well over this spectrum. We must learn to manipulate the environment and plants to obtain the desired results--whether for beauty, function, economy, or as will usually be the case, some optimum combination.

Broadly, we are concerned with the use of plants to enhance five environmental categories; urban, suburban, transitional, rural, and controlled. Urban environments carry with them the problems of the cities--crowding, damage, pollution, site disturbance, high maintenance effort, and high costs. The problems range from those of potted plants and trees along a downtown mall or in a roof garden, through parks and residential areas to industrial screening and noise abatement plantings. Suburban environments include problems of cities, but often to a lesser degree, and others associated with the disruption or modification of a previously rural setting. Transitional environments involve parts of central cities and the suburban sprawl, extending ultimately into the countryside, transportation corridors, airports, greenbelts, community forests, parks, and recreational areas. Rural environments range from semi-deserts to recreational woodlands and forests and mountain parks. Controlled environments include the increasingly popular enclosed shopping malls, lobbies, offices, hospitals, botanical gardens, greenhouses, and of course residences.

Presently we are utilizing many available plants without thoroughly determining their adaptability to a specific environment. Knowledge is too frequently lacking which will permit us to match plants with a given set of environmental conditions with assurance that both will be benefited.

Some of the conditions encountered in urban and suburban, transitional, rural and controlled environments are:

A. The Urban Environment

1. Downtown concrete canyons of our cities are among the most difficult areas for sustaining plant life. The scarcity of plants here makes them all the more valuable, yet their chance of survival are lessened by the existing conditions. Building construction has lowered water tables; the air is contaminated; the earth is compacted. Much of the rainwater is lost because a majority of the ground surface is paved. Salt, used for ice removal, seeps into the ground in the winter months; underground vaults and utility lines interfere with tree roots. Tall

buildings block and reflect natural sunlight and create "wind tunnels." Artificial light causes false extension of seasons. The resulting poor condition of the plants makes them even more susceptible to new and existing insects and diseases.

2. High rise developments, which almost fully utilize the land on which they are located, constitute the majority of new housing (public and private) in our central cities today. They create the same kinds of landscaping problems that exist in our downtown business areas.

3. Single family residences and one or two floor multiple family developments in cities usually have sufficient land space on which to grow a wider range of plants than in the more heavily populated areas of cities, but these must exist in the same general air mass and other unfavorable conditions.

4. City parks are taking on a different dimension. The current "parks-are-for-people" emphasis is resulting in more concentrated use of park areas and creating additional problems in sustaining plant life within these areas. The different types of parks found in our downtown areas vary from the typical city block park with large lawns and planting beds to completely paved small sidewalk sitting areas. In densely populated parts of the city, small vest pocket parks are being developed on lots surrounded by buildings on several sides.

5. Outdoor shopping malls are becoming an important element of downtown areas. They vary in size from median planting and development on existing streets on which traffic is retained, to an entire street on which traffic is banned. Depending on the amount and kind of use the area receives, plants are either placed in the ground or in raised or individual planters.

6. Increasingly shopping and business centers are being landscaped or rehabilitated. Good landscaping is now recognized by business and industry as having economic value. Often different types of landscape development and different materials are required from those found in parks and other areas. Usually there is

limited space and a heavy volume of pedestrian and vehicular traffic.

7. The use of planters in the urban environment is growing day by day. This is true not only for onground sites but also for roof gardens, hanging street planters, and other similar projects.

B. The Suburban Environment

1. Individual homesites in suburbia have markedly increased in number in recent years. Healthy and vigorous foundation and outlying plantings are recognized as major aspects of the pleasant surroundings and comparative privacy sought by owners of individual lots in developments or other areas with more extensive acreage.

2. More and more industries and government or public facilities are located in suburban areas. These create different landscape conditions and needs for plants commensurate with their use in each particular situation. The effect of industry on the environment also has an influence on the plants in adjacent areas.

3. Memorial parks, golf courses, recreational parks, botanical gardens, and conservation areas are often intertwined with residential areas. They are subjected to the pressures and heavy use associated with our increasing population and affluence.

C. The Transitional Environment

1. New freeways cross urban, suburban, and rural areas and each requires a different landscape treatment predicated on the available land, topography, safety requirements, and use potential of the land.

2. Rapid transit systems are being extended and developed in both our urban and suburban environments. These are placed either above or below ground, but create special landscape requirements in both locations.

3. Larger and faster planes are intensifying noise problems--particularly in new suburban areas built near existing airports. Vegetation is needed which can survive when subjected to the air blasts, pollution, and heat of these airport environments.

Plants must survive this environment while at the same time ameliorating it and helping to abate the noise. Likewise, helioports will be utilized more in our urban centers in the future. In many instances, these helioports will be located atop large buildings; in others, they will be located at ground level.

4. Greenbelts are being increasingly used by planners attempting to control urban sprawl and maintain open space. They either extend from the urban areas through the suburbs and out to the open countryside or form buffer zones between these separate areas. In some cases, these "strip parks" are used for recreation, but their final aim is conservation of existing green spaces.

D. The Rural Environment

1. Individual residences, town squares, community forests, and small parks in villages and small towns across the country involve the culture of plants for man's enjoyment. In many instances they afford settings for the enjoyment of rural people from miles around.

2. Shelterbelts and windbreak plantings around farmsteads often break the monotony of surrounding open areas of cultivated land. They are used primarily for protection of crops and fields, livestock, and farmsteads. They are also important for wildlife habitat and recreation.

3. Increasingly major highways through the countryside include plantings for esthetic and safety purposes. These plantings and associated vistas across farm and forest areas are significant parts of man's environment. In addition, roadside rest areas and overlooks are being developed on our more scenic freeway systems. These generate still different landscape requirements.

4. Recreation in rural areas involves management of native and introduced vegetation to produce the proper surroundings for human enjoyment and to reduce the impacts of human use on the vegetation and soil.

E. The Controlled Environment

1. Residences, offices, museums, theaters, conference centers, and hospitals--all these and more are made more liveable by the presence of growing plants or cut flowers. Increasing leisure time and affluence add to the demand for these amenities.

2. Enclosed malls and other special enclosed facilities, such as new large athletic plants, place a great challenge on designers and decorators to provide a natural element in the decor. Plants are exposed to comparable conditions the year round, which is in contrast to seasonal changes in our outdoor climate.

3. Greenhouses are used extensively in initial phases of the commercial production of nursery stock and the growth of cut flowers and related plants for the retail trade. Also, more small backyard greenhouses are being used by homeowners desiring year round greenery. Requirements for favorable growing conditions vary markedly by species and by season and geographic location.

RESEARCH PROGRAM

I. PRODUCTION

Problem:

Fundamental to the effective use of plants is the efficient production of high quality, low maintenance plant materials that will meet specific indoor and outdoor design needs, that will withstand the environmental stresses of our sophisticated society, and that will be available to the consumer in quantity and at costs which will encourage extensive use. Only recently has the magnitude of the problem and the need for research to produce plants to enhance man's environment been widely recognized; historically research inputs have been low.

The control of pests of plants in the city and suburban areas is very expensive. This cost could be greatly reduced if resistant native or exotic germ plasm could be located and used to breed new plants resistant to insects, diseases, nematodes, air pollutants, and chemicals used to remove ice. New varieties are needed that are suited to specific rural and urban designs. Many trees and woody ornamentals are difficult to propagate, resulting in high production costs thereby limiting their use. New developments in the use of light, and growth regulating chemicals need to be incorporated into plant production so that maximum desirable growth can be obtained in a minimum of time.

Blends of varieties of turf species are often sold without adequate evidence to support claimed merits. Breeding grass varieties for use in blends will require careful planning and testing of strains under a range of environmental conditions to determine the basis for mutual compatibility. Weeds rank as a major problem in turf production. New chemicals are needed to control certain species such as nimble-weed, nutsedge, bermudagrass, and annual blue grass. Nematodes in nursery sod are limiting intra- and interstate commerce.

The consumer demand and market availability of plants now are often at odds with each other. The consumer expects the various types of ornamental plants to have many esthetic characteristics incorporated into commercial cultivars. Most cut flowers have a restricted color range and develop unattractive off-colors as they mature. Most ornamental plants emit little or no fragrance components. Current commercial cultivars of rose and carnation emit little or no fragrance.

Losses to insects and diseases remain high even with the currently used applications of chemicals. Some mites and insects have developed resistance to insecticides which formerly gave effective control. Other problems encountered with the use of pesticides are their potentially hazardous nature, contribution to the environmental pollution problem, toxic effect on beneficial insects and only temporary relief afforded by chemical control measures.

Production costs need to be reduced by discovering new means to mechanize which will allow for standardization, reduced labor costs, and increased quantities of plants at reduced costs.

Research Needs:

A. Plant introduction, Evaluation, and Preservation

1. Discover plants with potential esthetic and functional characteristics for urban and rural areas.

2. Inventory newly discovered plants and evaluate their potential for esthetic and functional use.

B. Genetics and Breeding

1. Determine the genetics of "new" plant materials relative to their potential for breeding superior plants.

2. Develop improved plants:

a) To suit specific interior and exterior design purposes, including rural and urban development, parks, golf courses, industrial sites, home gardens, highways, turfgrass areas, etc.

b) To withstand particular environmental stresses such as air, water and soil pollution, cold, drought, fire, wind, etc.

c) To improve uniformity of response to the physical and biological environment in order to increase production efficiency, including mechanization and computer programming.

d) To determine the nature and inheritance of disease, nematode and insect resistance, with emphasis on developing disease, nematode and insect resistant plants.

C. Propagation

1. Develop more effective and efficient methods of propagation, including tissue culture techniques, particularly for turfgrasses and ground covers, trees, and woody and herbaceous perennials. Emphasis should be on morphogenesis, physiology, biochemistry and histochemistry of root initiation and development.

2. Develop procedures for producing propagative materials free of plant pathogens and insects, with emphasis on virus diseases.

D. Culture

1. Determine the response of plants to the physical environment (temperature, light, moisture, atmospheric gases, nutrients, etc.), with emphasis on optimal "integration" of these factors for increased efficiency of plant growth and improved plant form.

2. Develop procedures for more efficient growth of trees and woody perennials, giving particular attention to the problem of over-wintering of container grown plants and to production practices which would enhance survival and growth upon transplanting to permanent sites.

3. Determine the nature and activity of plant growth substances and chemicals influencing morphogenesis, with emphasis on:

a) The nature and regulation of dormancy in plants, particularly trees, woody perennials and bulbs

b) The regulation and/or control of cultural practices such as mowing, pruning, disbudding

c) The regulation and/or control of growth habit and flowering.

4. Determine cultural requirements for "new" native, non-native and exotic plants.

E. Protection

1. Diseases:

a) Determine the diseases that may be introduced with "new" plant species and their importance to:

1) The potential of these plant species for esthetic and functional use.

2) The hazard that such diseases would present to the production of existing plants.

b) Determine the physical and biological factors that cause disease epidemics to occur during the production of plants; determine how these factors may be altered to achieve disease control. Emphasis should be placed on:

1) The fungus, bacterial, and nematode diseases of turfgrasses and ground covers, trees, and woody perennials.

2) Virus diseases of woody perennials, cut flowers, pot plants and bedding plants, including insect vector-virus relationships.

3) The development of systemic and protectant chemicals, including plant growth substance and regulators, for efficient and effective disease control.

c) Determine the nature of air pollution injury, including:

1) The types, concentration and exposure times which induce injury.

2) The effect of low concentration, long time exposure in inducing injury in trees and woody ornamentals.

3) The determination of resistant species, varieties, and cultivars.

4) The role of air pollutants in increasing the susceptibility of plants to other diseases and environmental stresses.

5) The influence of theraputants on increasing plant tolerance to specific air pollutants.

2. Insects:

a) Determine indigenous and introduced insect pest species in order to retard the extension of infestations into new areas and reduce the threat of the introduction of

destructive insect pests via modern, rapid means of transport and on introduced plant materials.

b) Determine insect vector-virus relations, and differentiate the injurious effects of direct insect feeding, relative to the development of procedures for producing pathogen-free propagating material and avoiding the dissemination and establishment of host plant reservoirs of viruses.

c) Determine the biology, ecology, physiology, and population dynamics of insects attacking plants, with emphasis on the influence of the environment on the development of insect populations in order to select plant species, varieties, and cultivars for particular ecological situations.

d) Develop more efficient and effective insect control measures, with emphasis on the biological control of insect populations through the use of parasites, predators and pathogens, sterility phenomena, attractants, and growth regulators.

e) Develop more efficient and effective pesticides for use in insect control programs that:

1) can be adapted for nurseries and greenhouses

2) can be adapted for safe use by the home owner

3) will allow for the survival of parasites and predators in an effective integrated insect pest control program.

3. Weeds:

a) Determine the mode of action of herbicides.

b) Develop selective herbicides and mechanical methods for use, that can be safely used in production plantings. Attention should be given to the development of herbicide-mulch combinations which facilitate uniform application of herbicides as well as providing benefits of the mulch.

c) Determine the ecological patterns of weeds growing in association with various ornamentals and turfgrasses.

F. Mechanization (Engineering)

1. Develop and use a systems approach to mechanization, with

emphasis on:

a) Mechanizing production practices such as direct seeding, watering, fertilizing, the application of pesticides, harvesting, seed production, etc.

b) Developing mechanized control systems to regulate and/or control the environment for increased efficiency of plant growth.

2. Develop and use new types of enclosed structures for more efficient plant growth.

Manpower Needs:

An increase in manpower of 224 SMY's in the next 10 years is recommended.

Table 2

Summary of scientist man-years (SMY's) in production research:

Commodity	SMY's	
	Estimated 1966 base	Projected 1977 total
Turfgrass, etc.	6	47
Trees	22	97
Perennials and bulbs	53	103
Cut flowers, etc.	86	144
TOTAL	167	391

Additional detail about the SMY's is presented in tables near the end of the report.

II. ESTABLISHMENT AND MAINTENANCE

Problem:

The establishment and maintenance of plants presents an infinite number of problems. All environments have their own particular problems for plant growth, in addition to the many problems common to all. We also must consider the great variability in environment as we move from place to place about the nation. Here in the contiguous States, man's environment ranges through 24° of latitude, 55° of longitude, and 7,000 feet or more of elevation. As we move from one city to another or even from one side of a building to another, we encounter a change in environment.

Man through use, site disturbance, and pollution generates new problems of establishment and maintenance. The combinations of environments and plants are infinite and we can only hope to attack and solve the major problems.

There is information available on many problems but it is inadequate to meet the needs of our growing society. Major knowledge gaps are evident on problems associated with growth of plants in urban and suburban environments, particularly on the disturbed sites resulting from construction activities. The species and varieties which may be effectively used on each site are not known. We know little about the effects of heavy use of areas and the prevention of damage to the area and its plants. Insects, diseases, and air pollution pose major maintenance problems. Cultural practices and reduction of storm damage are interrelated aspects of the overall problem.

Research Needs:

A. Site conditions

1. Relate site conditions to particular kinds of plants and to plant growth:

a) Soil depth and texture, fertility, and moisture relationships,

b) Climatic conditions for both micro and macro sites, including the effects of exposure, shading and wind, and their influence on susceptibility of plants to insect and disease attack.

c) Air, water and soil pollution problems, including salt from highways, etc.

d) Soil organism and plant relationships, (including mycorrhiza and latent soil organisms that attack plant roots), particularly on newly established plants.

2. Define site requirements for various species and the relative performance of species and varieties.

3. Determine the tolerance of plants to kinds of man-use and man-use levels on various sites.

B. Site preparation

1. Develop site preparation practices to insure successful establishment and subsequent growth of artificially and naturally established plants:

a) Preparation practices for natural regeneration, seeding and planting on undisturbed sites.

b) Preparation and amelioration of disturbed and adverse sites for selected species.

2. Improve present or develop new planting and seeding methods (including equipment) to insure high success in establishment:

a) On disturbed sites such as where top soil is absent, fill areas, cuts, etc.

b) On natural sites such as community forests, parks, and transportation and utility rights-of-way

c) When lifting, transplanting, and holding native plants for replanting after site development.

3. Develop protective and rehabilitative measures needed on and around construction sites, especially where cuts and fills are involved and where soil moisture relationships may be affected. Studies are needed of changes in the hydrologic profile and in the ecological relationships where ground cover is changed.

C. Protection

1. Insects:

a) Identify domestic insect problems and develop safe control measures that are economically feasible for all categories of users (home-owners, public, commercial).

b) Identify and study potentially dangerous insects on other continents that may be accidently introduced to the U.S. some time in the future.

2. Diseases and nematodes:

a) Identify disease and nematode problems and develop safe control measures that are economically feasible for all categories of users.

b) Identify and study potentially dangerous diseases and nematodes on other continents that may be accidently introduced to the U.S. at some time in the future.

c) Seek protective measures to permit plant growth under conditions of soil, air, or water pollution.

3. Weeds:

a) Develop selective chemicals and cultural practices for control of broad-leaved weeds and undesirable grasses.

4. Wind and frost heaving:

a) Develop methods for using artificial devices, nurse plants, or other approaches to protect trees, shrubs, and other perennials during the establishment phase. The major concern is protection from environmental hazards, but studies should include the use of mixed plantings to reduce insect and disease damage.

D. Culture

1. Determine competition factors where several species or varieties of grass are grown in blends and identify blends of grasses that can be maintained on a permanent basis to provide seasonal dominance and to meet other specific needs.

2. Develop methods of stimulating root growth to speed the establishment of sod and vegetatively propagated turf.

3. Determine best mowing heights to maintain optimum turf vigor under adverse conditions.

4. Improve thatch removal methods to maintain turf appearance and to reduce insect and disease problems.

5. Develop growth retardants to reduce mowing and maintenance costs, and minimize disease and insect problems.

6. Develop effective ways to renovate existing lawns and playing fields, particularly to overcome wear and trampling of turf and compaction of soil.

7. Determine the establishment periods for various species and varieties of trees and woody ornamentals in different situations and develop methods to shorten this period. This involves the determination of the period of intensive care needed to insure survival and to stimulate rapid early growth.

8. Improve cultural measures to reduce competition of other plants with trees and woody ornamentals.

9. Develop indices of competition among plants to insure proper stand density control (level of competition) so that plants will remain vigorous.

10. Develop improved methods of moisture control and economically feasible watering systems to serve during the critical establishment period for trees and woody ornamentals, including use of anti-transpirants.

11. Determine methods of pruning and shaping trees and shrubs for best esthetics to insure establishment and to minimize maintenance costs. Particularly important are pruning methods to reduce damage by ice and snow.

Manpower Needs:

An increase of 149 SMY's over the next 10 years is recommended

TABLE 3

Summary of scientist man-years (SMY's) in establishment and maintenance research.

Commodity	SMY's	
	Estimated 1966 base	Projected 1977 total
Turfgrass, etc.	26	42
Trees	73	181
Perennials and bulbs	15	39
Cut flowers, etc.	--	--
TOTAL	114	262

Additional detail about SMY's is presented in tables near the end of the report.

III. MARKETING

Problem:

Production centers for plants are developing and expanding in the most favorable climates for specific plants. California and Florida have particularly favorable winter climates for certain plants and the Midwest and New England have advantages for others. The products must be transported great distances, stored and marketed at the right time. Proper preparation for shipment and storage can add greatly to consumer satisfaction. Preshipping treatment may also prevent the spread of noxious weeds, pests or diseases.

Trees, ornamentals, turf, and related crops have not been adequately recognized as agricultural production. As a result, there are only meager data on production, marketing, and price relationships. There is a need to establish basic series of production, marketing and price data. There is also a need for economic research into problems of marketing, production, and management. Such data would be useful in determining the relative position of these plants for both production and distribution, in establishing guides for industry growth and as a basis for further research. They would also be useful to SAES and Extension Service personnel in advising and counseling constituents in the individual States.

Research Needs:

A. Physical and biological efficiency

1. Determine the most efficient systems for packaging, handling, transporting and storing woody plants, container plants, cut flowers and propagative materials, including effects of the transit and storage environment on the post harvest life and physiology of these products.

2. Develop preshipping or in-transit treatments such as dips or fumigants to eliminate the spread of insects, disease, noxious weeds or other pests on domestic or foreign shipments of cut flowers, propagative material, woody plants, and turf.

B. Market structure and economic efficiency: production, pricing, and quality

1. Establish series of data on production, prices and marketing of trees, ornamentals, turf, and related plants. Data comparable to that maintained for fruits, vegetables, and other agricultural products should be collected periodically and maintained or kept up-to-date. The USDA would have primary

responsibility for collecting these data through periodic surveys from production areas, shipping points, wholesale markets, or retail and service trade on a national basis.

2. Establish and conduct economic research including production cost and management analysis, market structure, inter-regional competition, marketing costs, and price analyses.

Manpower Needs:

An increase of 27 SMY's is recommended for the next 10 years.

TABLE 4

Summary of scientist man-years (SMY's) in marketing research.

Commodity	SMY's	
	Estimated 1966 base	Projected 1977 total
Turfgrass, etc.	--	6
Trees	--	6
Perennials and bulbs	8	15
Cut flowers, etc.	11	19
TOTAL	19	46

Additional detail about SMY's is presented in tables near the end of the report.

RESEARCH RESPONSIBILITIES

Close teamwork among industry, government, Land Grant Universities, State Agricultural Experiment Stations, and foundations, offers the best opportunity for utilizing the limited resources and numbers of scientifically trained personnel available for research in the much neglected field of plants to enhance man's environment.

The task force recognizes that ideal division of responsibilities among the State Agricultural Stations, USDA, and private industry may vary by State, region, species, problem uses, and the use to be made of the research. However, the following general guidelines for the next ten years are suggested.

Private business should be expected to conduct applied research and developmental projects necessary to the success of their business and where a suitable return on the investment can be projected. Tax-supported and endowed institutions should focus on basic research that will add to the current knowledge about such things as plant growth and development and methods of pest control, and to the development of new information on agricultural engineering principles and agricultural economic relationships. Applied research should be conducted by the State Agricultural Experiment Stations and the USDA for the benefit of the public, whenever private industry leaves a void and the need for obtaining such information is consistent with the needs and priorities established in the National Program of Research for Agriculture.

Private industry currently is doing most of the varietal development of annuals, cut flowers, and certain perennials such as roses. This interest is expected to continue and to expand. Industry is also expected to continue its leadership in developing improved new chemicals for pest control, improving mechanized equipment and developing mechanized production techniques.

State Agricultural Experiment Stations and Forestry schools are responsible for working on local, State, and regional problems such as: developing cultural practices peculiar to the soil and environmental conditions; testing and recommending plants for culture; evaluating new pesticides and developing recommendations for control; developing methods of propagation needed by industries; and collecting and analyzing cost statistics for production and marketing studies.

The USDA should concentrate its resources on research with broad regional or national implications affecting the public and industry as a whole and on problems encountered on a wide geographical basis, or where data are

needed to complement plant quarantines or control programs which require action by the Federal Government.

Foreign plant exploration for new germ plasm and its preservation can best be done by the USDA. Other examples of areas of prime responsibility for the Federal Government include research on shelterbelts, including field and farmstead windbreaks; maintenance of large collections of and taxonomic studies on, plants, insects, nematodes, and plant pathogens; problems associated with inter- and transcontinental shipping of plant materials; the collection of national statistics on market development and prices; as well as problems associated with the maintenance and operation of Federal lands such as the National Forests. In pest control the USDA should emphasize research on problems involving extensive geographic areas and on developing new principles of control, such as the male sterile technique for insects.

Federal and State research agencies both need to develop materials and methods for chemically controlling pests and plant growth of crops where the profit potential is not sufficient to attract the interest of private industry. The development of non-chemical pest control measures also will continue to be a joint State and Federal responsibility. Varietal development should be primarily the responsibility of private breeders. Federal and State agencies should concentrate on locating valuable germ plasm and introducing it into basic breeding stocks that can be released for use by others to develop varieties adapted to the different production and use areas.

The evaluation of certain kinds of germ plasm now done jointly by the USDA and the State Experiment Stations under four regional projects and one inter-regional project, is very effective and should continue. Private and public botanic gardens will continue to perform an important function in preservation of stocks and deserve assistance in development of a nationwide inventory to make these resources known and available.

The task force has determined that there are several centers of excellence in each of the major regions of the U.S. It is recommended that as the research proposed in this report is expanded, primary consideration should be given to allocating the projected SMY's to such centers. Close coordination should also be maintained with the Department of Housing and Urban Development, the Department of Transportation, Department of the Interior, and State and local governmental agencies which have an interest and may in certain instances carry out research programs of their own, in this area. It is essential that unnecessary duplication of research effort be avoided.

MANPOWER NEEDS

The task force estimated that in FY 1966, 300 scientific manyears (SMY's) were conducting research in this area. It projects an increase of 399 additional SMY's for a total need of 699 at the end of ten years. The requirements for manpower are summarized in Tables 5 to 9.

Table 5 summarizes the data from Tables 1 to 4, with further division by SAES and USDA. Tables 6 to 9 present breakdowns of current and projected SMY's for the several research problem areas involved in the research program.

The task force wishes to emphasize the importance of funding educational institutions so that an adequate supply of well-trained scientists is available for the manpower requirements for State and Federal research agencies as well as for the needs of private industry.

TABLE 5

Summary of scientist man-years (SMY's) for research on Plants to Enhance Man's Environment giving SMY's for estimated base 1966 and projected 1977 total for State Agricultural Experiment Stations and USDA

RESEARCH	AGENCY	COMMODITY								ALL COMMODITIES	
		Turf, etc.		Trees		Perennials & bulbs		Cut Flowers, etc.		TOTAL	
		'66	'77	'66	'77	'66	'77	'66	'77	'66	'77
Production	SAES	5	36	8	29	42	75	64	109	119	249
	USDA	1	11	14	68	11	28	22	35	48	142
	Total	6	47	22	97	53	103	86	144	167	391
Establishment & Maintenance	SAES	25	35	15	43	15	31	--	--	55	109
	USDA	1	7	58	138	--	8	--	--	59	153
	Total	26	42	73	181	15	39	--	--	114	262
Marketing	SAES	--	4	--	5	8	12	8	12	16	33
	USDA	--	2	--	1	--	3	3	7	3	13
	Total	--	6	--	6	8	15	11	19	19	46
All Research	SAES	30	75	23	77	65	118	72	121	190	391
	USDA	2	20	72	207	11	39	25	42	110	308
	TOTAL	32	95	95	284	76	157	97	163	300	699

TABLE 6

Summary of scientist man-years (SMY's) for research on Plants to Enhance Man's Environment giving SMY's by Research Problem Area (RPA)

RPA	YR.	COMMODITY								ALL COMMODITIES		TOTAL
		Turf		Trees		Woody		Perennials & bulbs				
		SAES	USDA	SAES	USDA	SAES	USDA	SAES	USDA	SAES	USDA	USDA & SAES
905	'66	--		11	18	--	--	--	--	11	18	29
	'77	--		44	82	--	--	--	--	44	82	126
906	'66	30	2			65	11	72	25	167	38	205
	'77	75	20			116	38	115	39	306	97	403
103	'66	--	--	--	--	--	--	0	0	0	0	0
	'77	--	--	--	--	--	--	2	1	2	1	3
105	'66	--	--	--	--	--	--	0	0	0	0	0
	'77	--	--	--	--	--	--	2	1	2	1	3
201	'66	--	--	6	31	--	--	--	--	6	31	37
	'77	--	--	14	75	--	--	--	--	14	75	89
202	'66	--	--	6	23	--	--	--	--	6	23	29
	'77	--	--	16	46	--	--	--	--	16	46	62
214	'66	--	--	--	--	--	--	--	--	--	--	--
	'77	--	--	3	4	2	1	2	1	7	6	13
TOTAL	'66	30	2	23	72	65	11	72	25	190	110	300
	'77	75	20	77	207	118	39	121	42	391	308	699

TABLE 7

Summary of scientist man-years (SMY's) for Production Research giving estimated 1966 base and projected 1977 total for individual research problem areas (RPA's) for SAES and USDA

RPA	YR.	COMMODITY												ALL COMMODITIES		
		Turf, etc.			Trees			Perennials & bulbs			Cut flowers, etc.			Total		
		SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
905	'66	--	--	--	2	3	5	--	--	--	--	--	--	2	3	5
	'77	--	--	--	11	40	51	--	--	--	--	--	--	11	40	51
906	'66	5	1	6	--	--	--	42	11	53	64	22	86	111	34	145
	'77	36	11	47	--	--	--	73	27	100	103	32	135	212	70	282
103	'66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	'77	--	--	--	--	--	--	--	--	--	2	1	3	2	1	3
105	'66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	'77	--	--	--	--	--	--	--	--	--	2	1	3	2	1	3
201	'66	--	--	--	3	6	9	--	--	--	--	--	--	3	6	9
	'77	--	--	--	7	14	21	--	--	--	--	--	--	7	14	21
202	'66	--	--	--	3	5	8	--	--	--	--	--	--	3	5	8
	'77	--	--	--	8	10	18	--	--	--	--	--	--	8	10	18
214	'66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	'77	--	--	--	3	4	7	2	1	3	2	1	3	7	6	13
TOTAL all RPA's	'66	5	1	6	8	14	22	42	11	53	64	22	86	119	48	167
	'77	36	11	47	29	68	97	75	28	103	109	35	144	249	142	391

TABLE 8

Summary of scientist man-years (SMY's) for Establishment and Maintenance Research giving estimated 1966 and projected 1977 total for individual research problem areas (RPA's) for SAES and USDA

RPA	YR.	COMMODITY												ALL COMMODITIES		
		Turf, etc.			Trees			Perennials & bulbs			Cut flowers, etc.			Total		
		SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
905	'66	--	--	--	9	15	24	--	--	--	--	--	--	9	15	24
	'77	--	--	--	28	41	69	--	--	--	--	--	--	28	41	69
906	'66	25	1	26	--	--	--	15		15	--	--	--	40	1	41
	'77	35	7	42	--	--	--	31	8	39	--	--	--	66	15	81
201	'66	--	--	--	3	25	28	--	--	--	--	--	--	3	25	28
	'77	--	--	--	7	61	68	--	--	--	--	--	--	7	61	68
202	'66	--	--	--	3	18	21	--	--	--	--	--	--	3	18	21
	'77	--	--	--	8	36	44	--	--	--	--	--	--	8	36	44
TOTAL all RPA's	'66	25	1	26	15	58	73	15	--	15	--	--	--	55	59	114
	'77	35	7	42	43	138	181	31	8	39	--	--	--	109	153	262

TABLE 9

Summary of scientist man-years (SMY's) for Marketing Research giving estimated 1966 base and projected 1977 total for individual research problem areas (RPA's) for SAES and USDA

RPA	YR.	COMMODITY												ALL COMMODITIES		
		Turf etc.			Trees			Perennials & bulbs			Cut flowers, etc.			Total		
		SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
905	'66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	'67	--	--	--	5	1	6	--	--	--	--	--	--	5	1	6
906	'66	--	--	--	--	--	--	8	--	8	8	3	11	16	3	19
	'67	4	2	6	--	--	--	12	3	15	12	7	19	28	12	40
TOTAL all RPA's	'66	--	--	--	--	--	--	8	--	8	8	3	11	16	3	19
	'77	4	2	6	5	1	6	12	3	15	12	7	19	33	13	46